
(12) UK Patent Application (19) GB (11) 2 056 424 A

(21) Application No 8024800

(22) Date of filing 29 Jul 1980

(30) Priority data

(31) 79/27702

79/30980

(32) 8 Aug 1979

6 Sep 1979

(33) United Kingdom (GB)

(43) Application published

18 Mar 1981

(51) INT CL³

B01D 53/36

(52) Domestic classification

C1A S23X S801 S602

S60X S60Y S611 S613

S618 SA

(56) Documents cited

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"Ozone, Its Manufacture,

Properties and Uses" by

A. Vosmaer Constable &

Co. Ltd. (London) 1916 at

pp. 10—23

(58) Field of search

C1A

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(54) Decomposition of ozone

(57) A process for the removal of ozone from a mixture of gases, containing ozone, comprises passing the mixture of gases over a catalyst such that at least a portion of the

ozone undergoes catalytic decomposition into oxygen, the said catalyst comprising catalytic material including one or more of Pt, Ru, Rh, Pd, Ir, Os, Fe, Co, Ni, Ag, Mn and Sn alloys, mixtures and compounds containing one or more of these metals.

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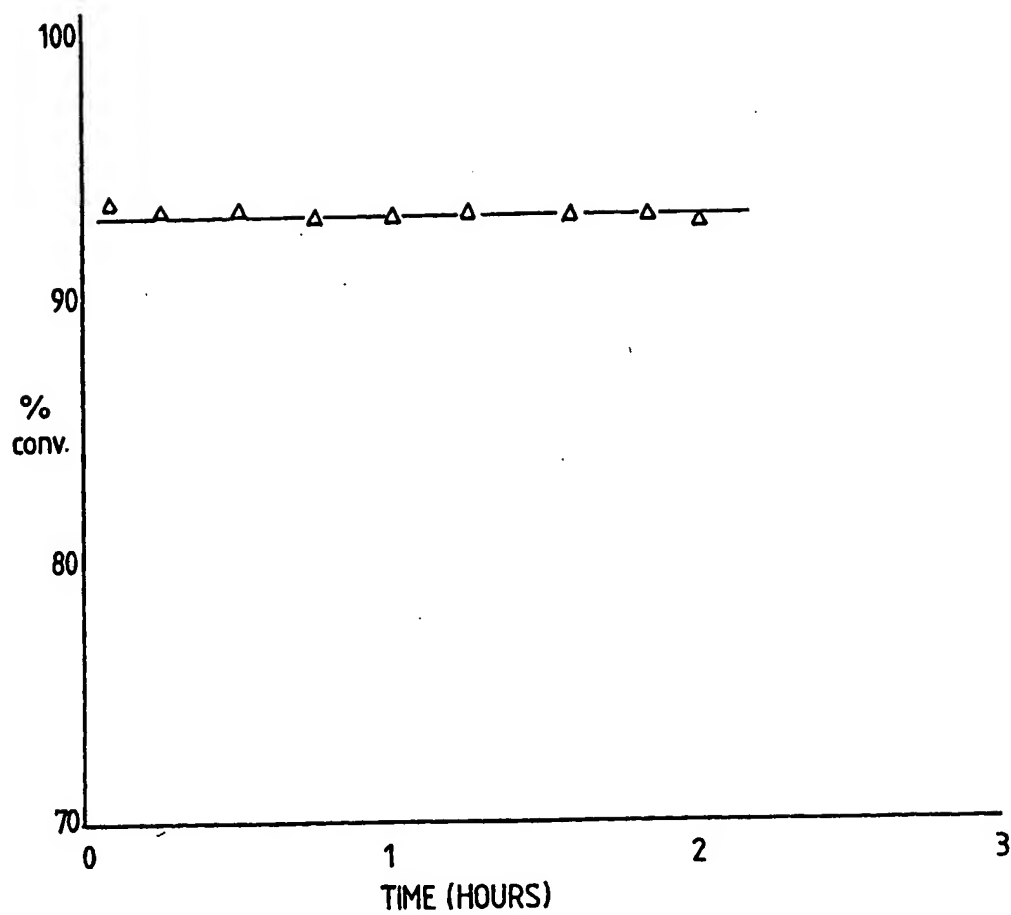


Fig.1.

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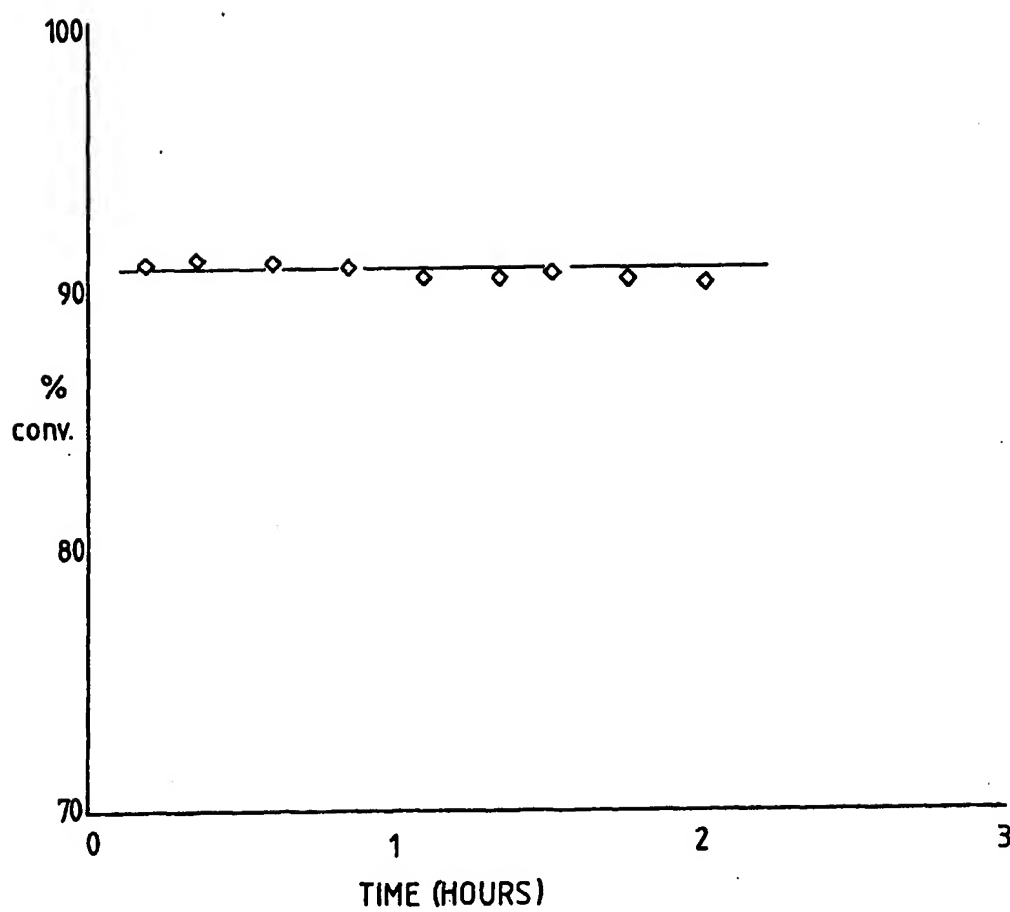


Fig.2.

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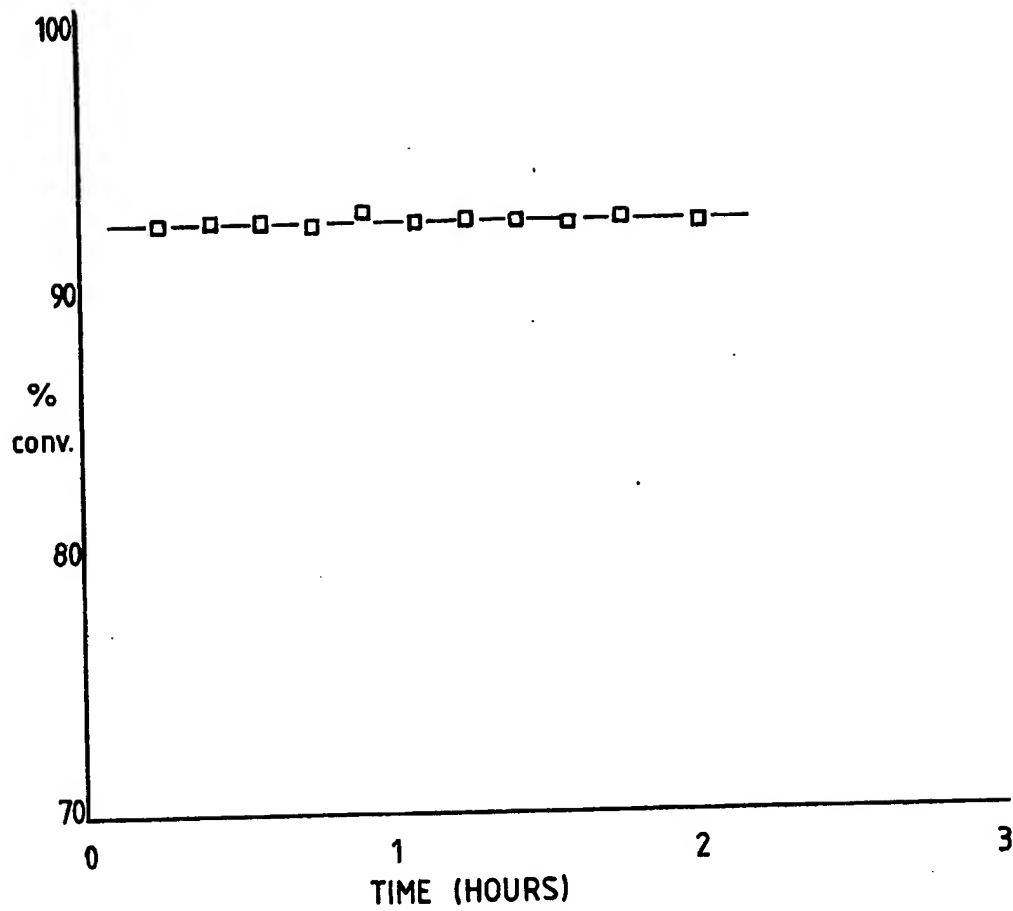


FIG. 3.

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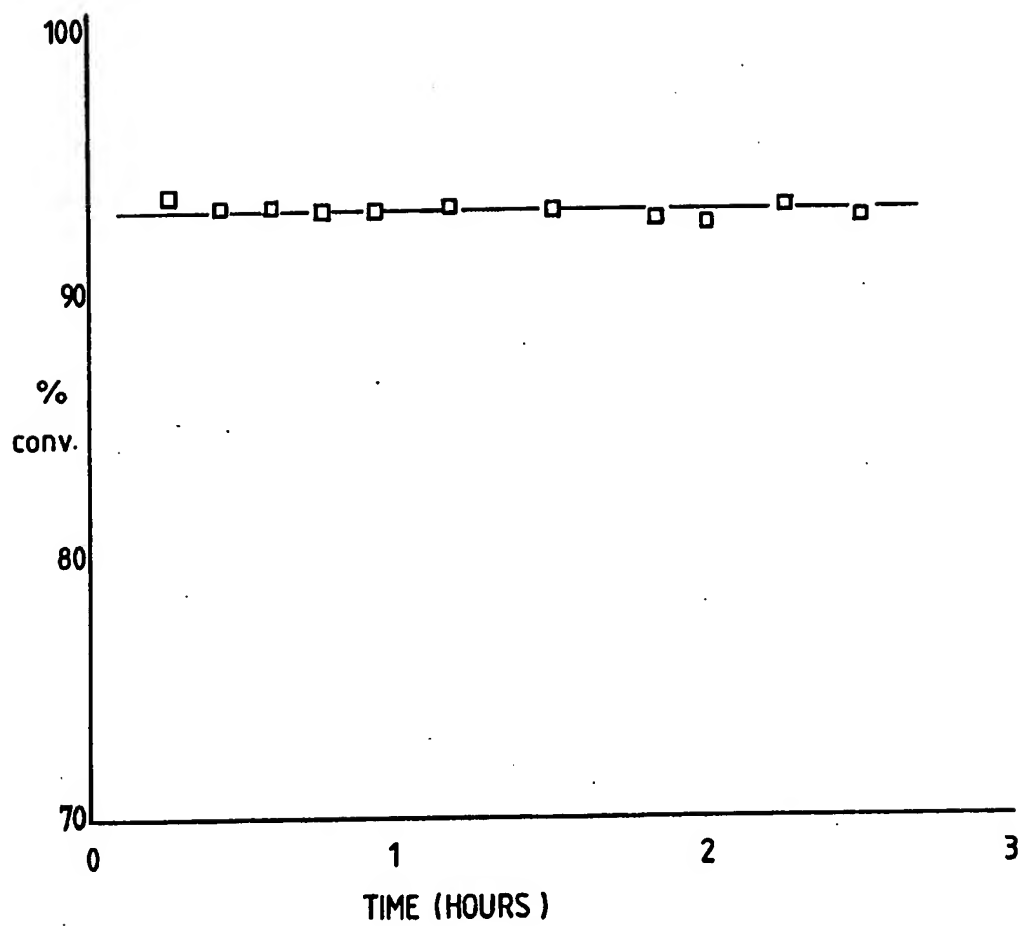


Fig.4.

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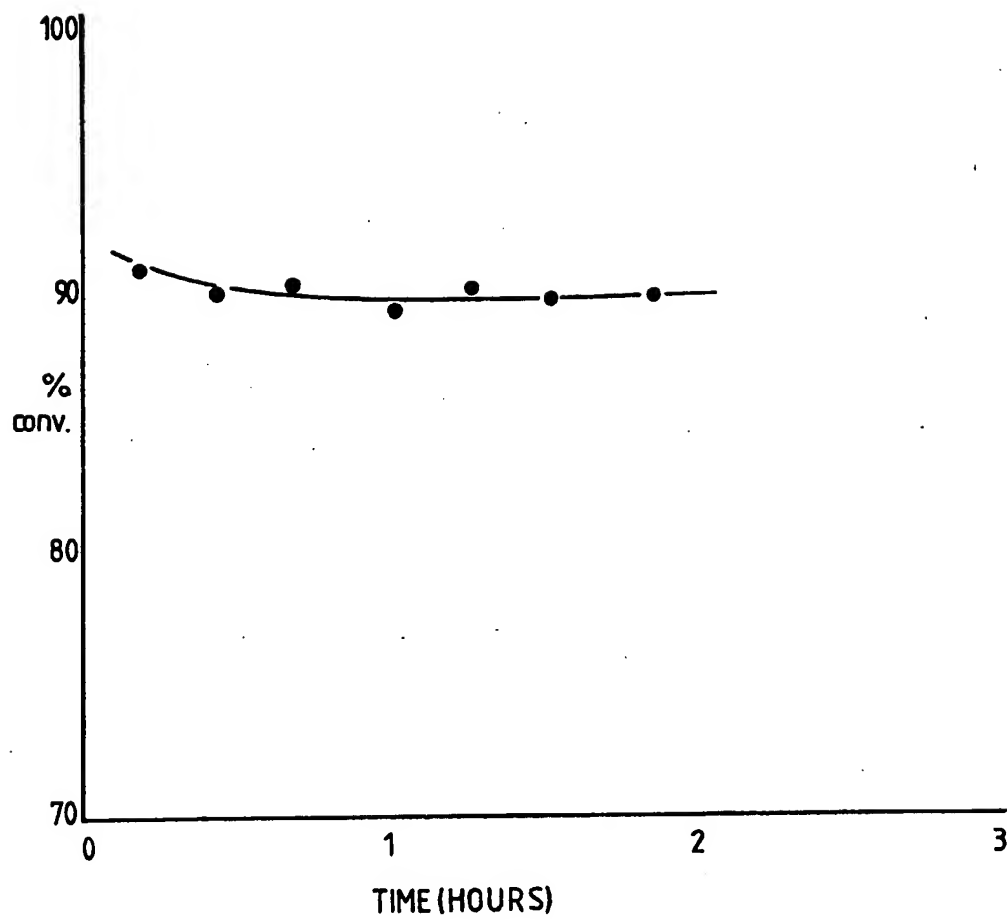


Fig.5.

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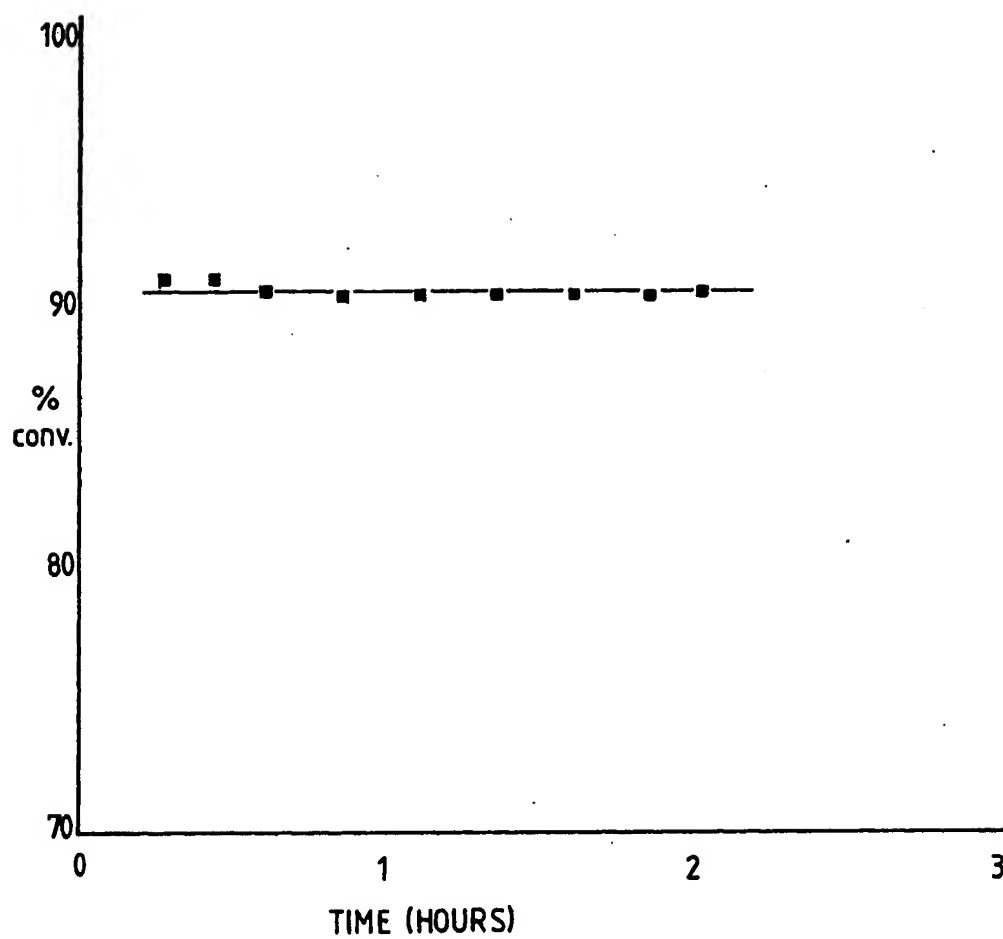


Fig.6.

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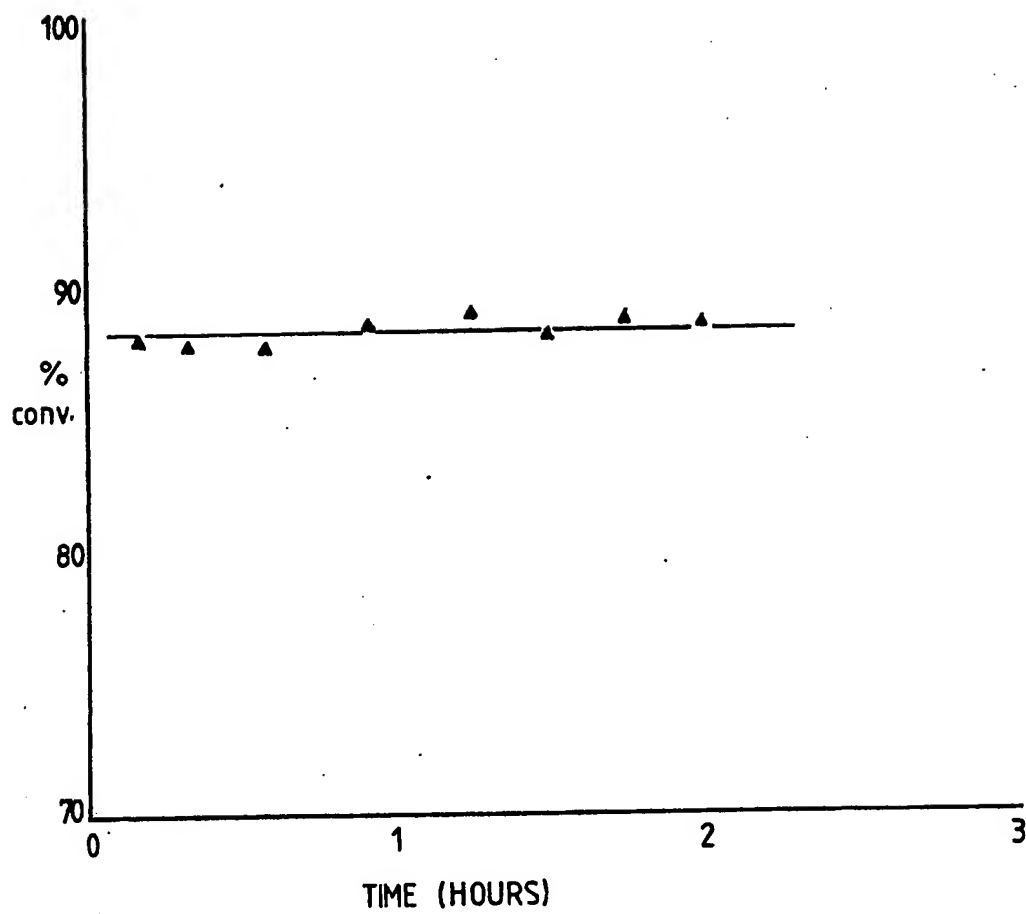


Fig.7.

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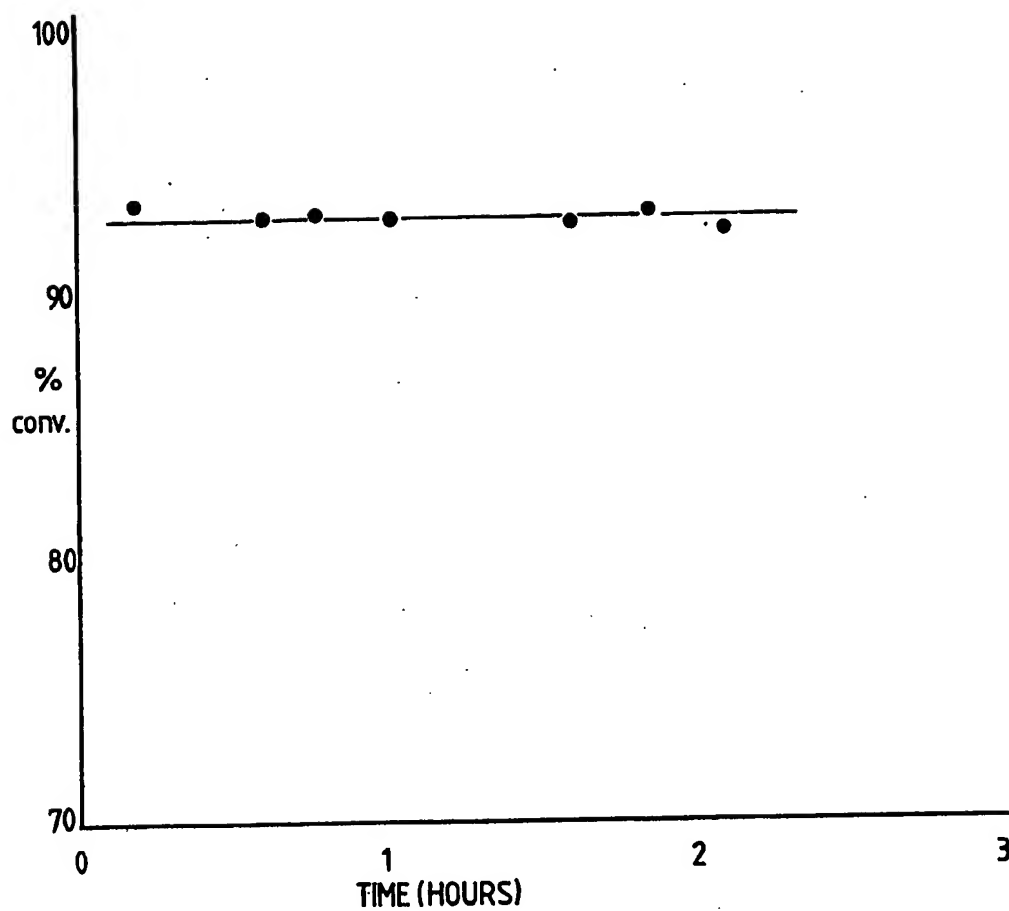


Fig.8.

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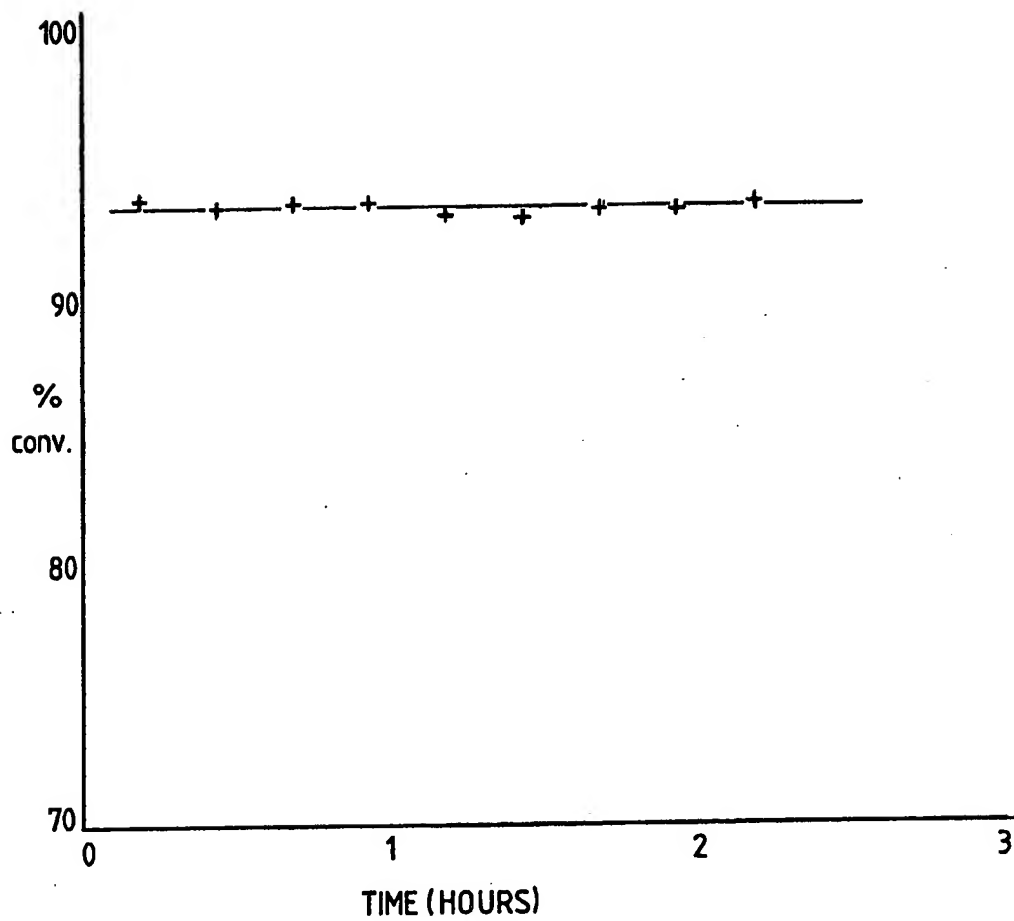


Fig.9.

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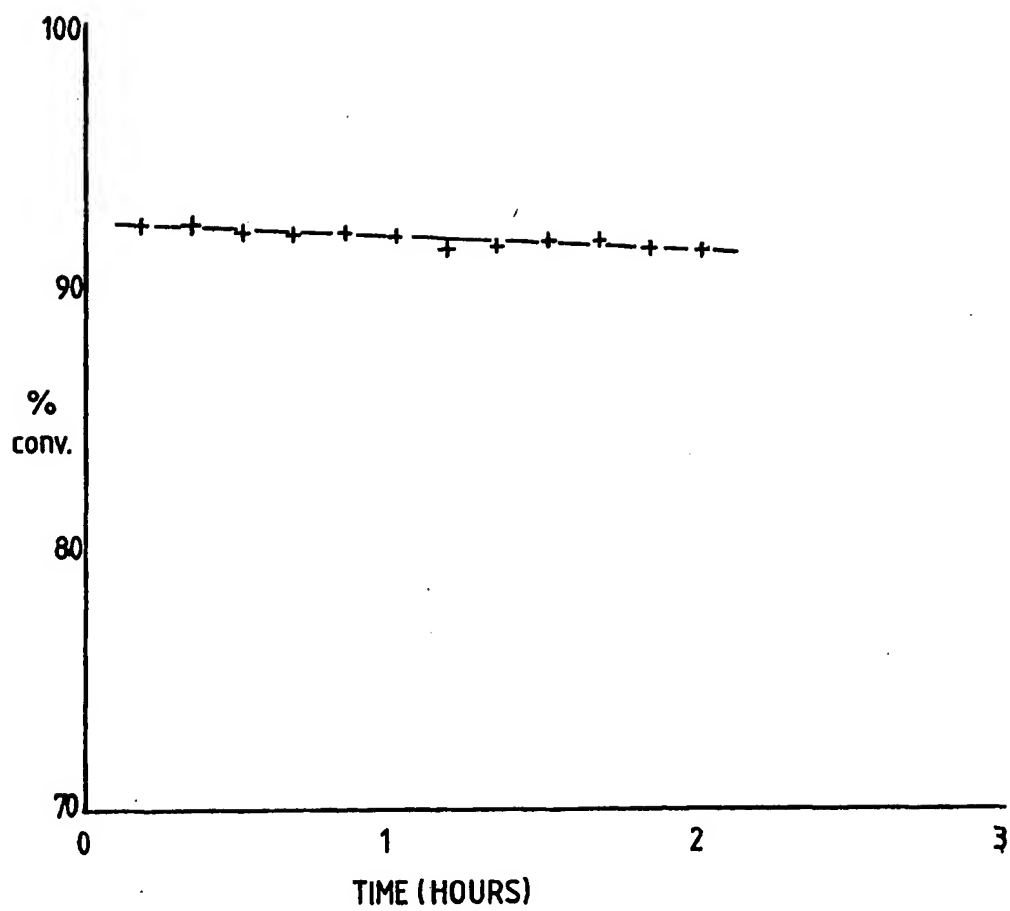


Fig.10.

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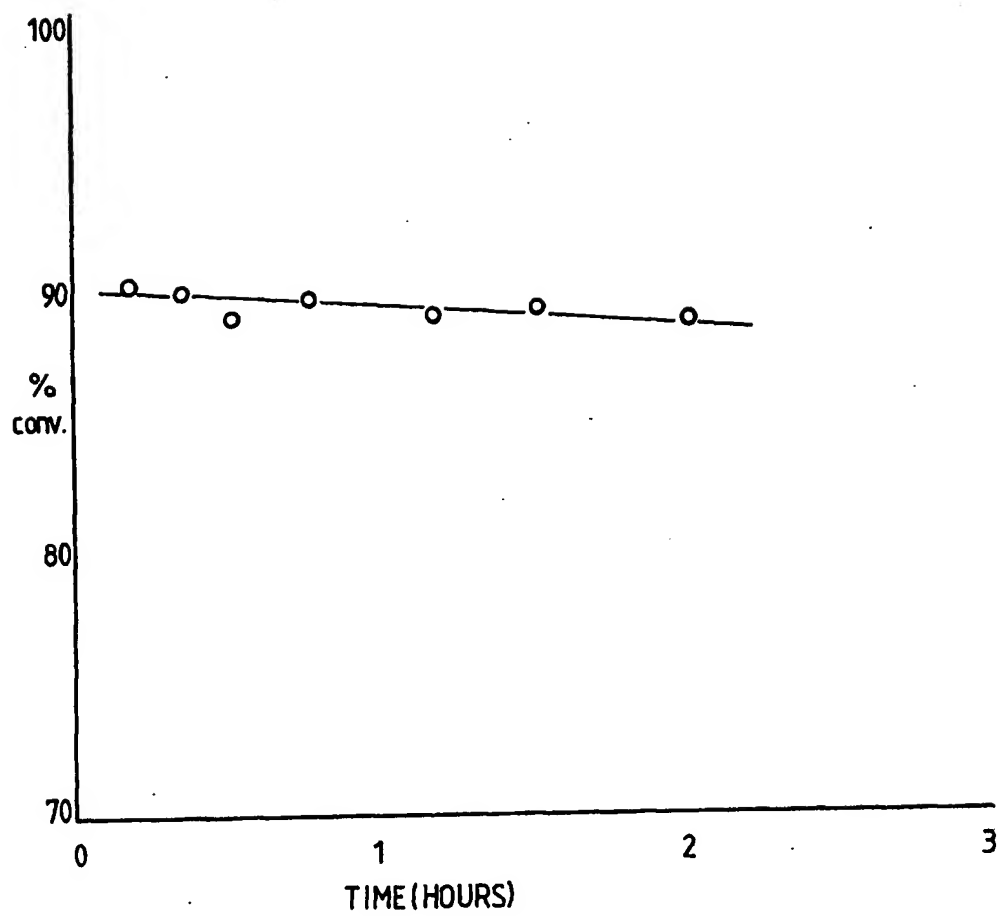


Fig.11.

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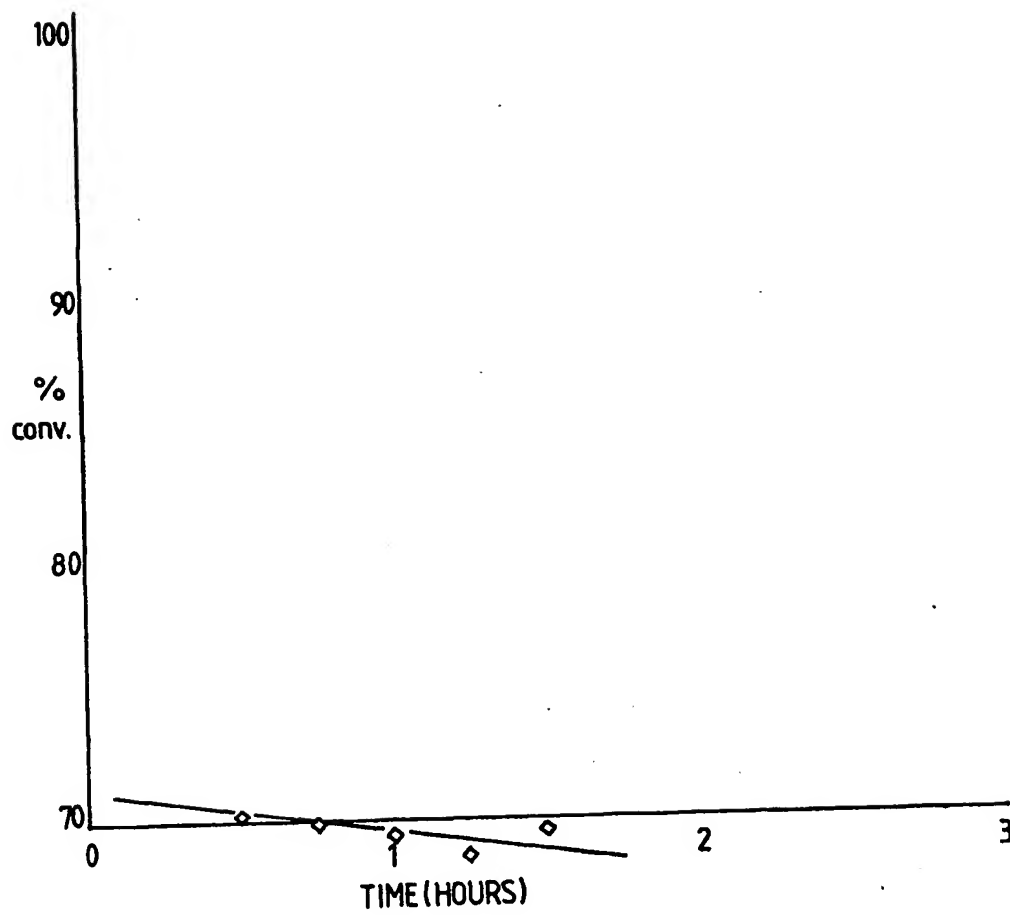


Fig.12.

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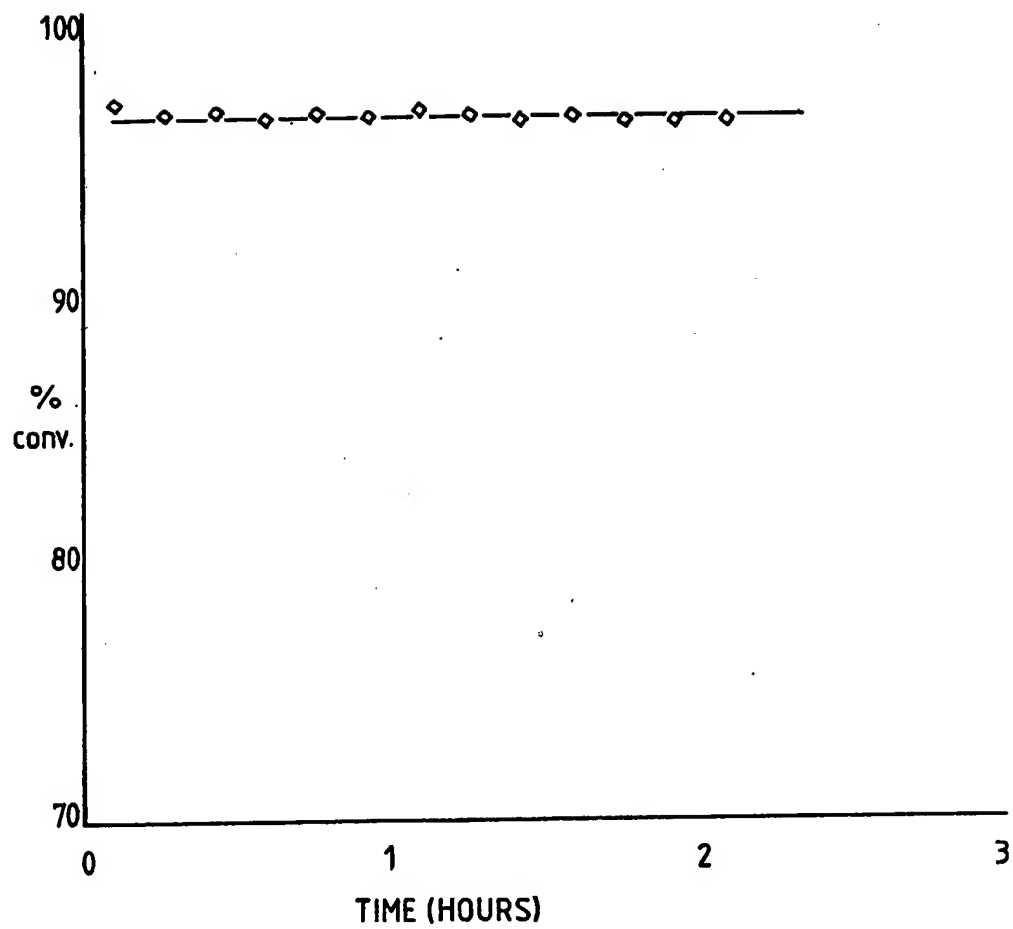


Fig.13.

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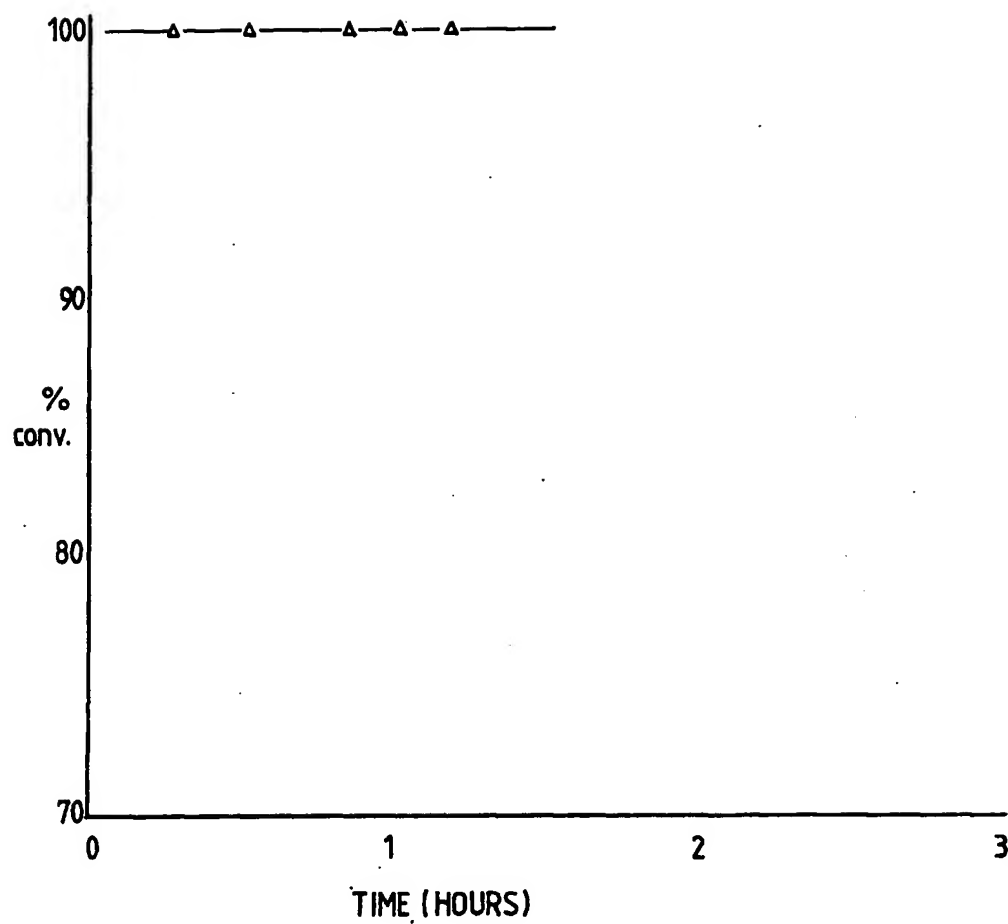
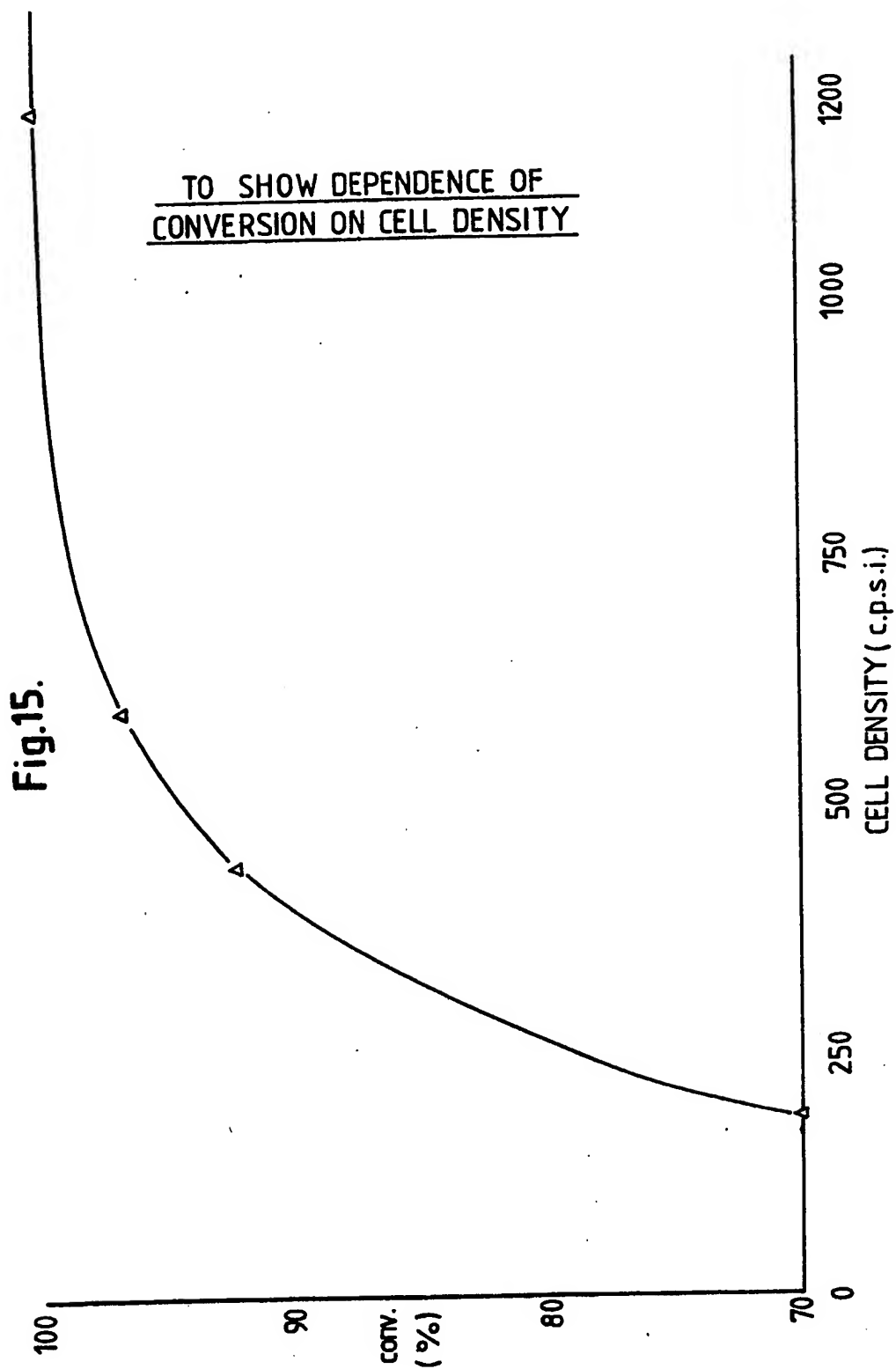


Fig.14.

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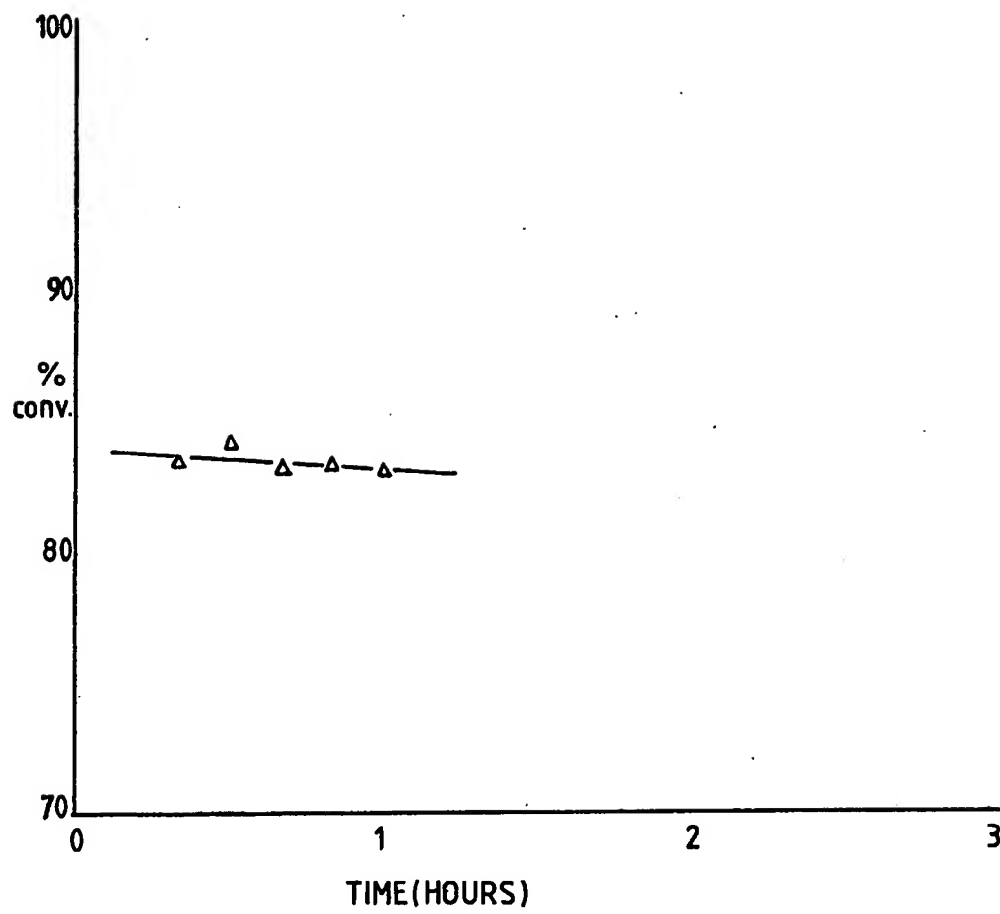


Fig.16.

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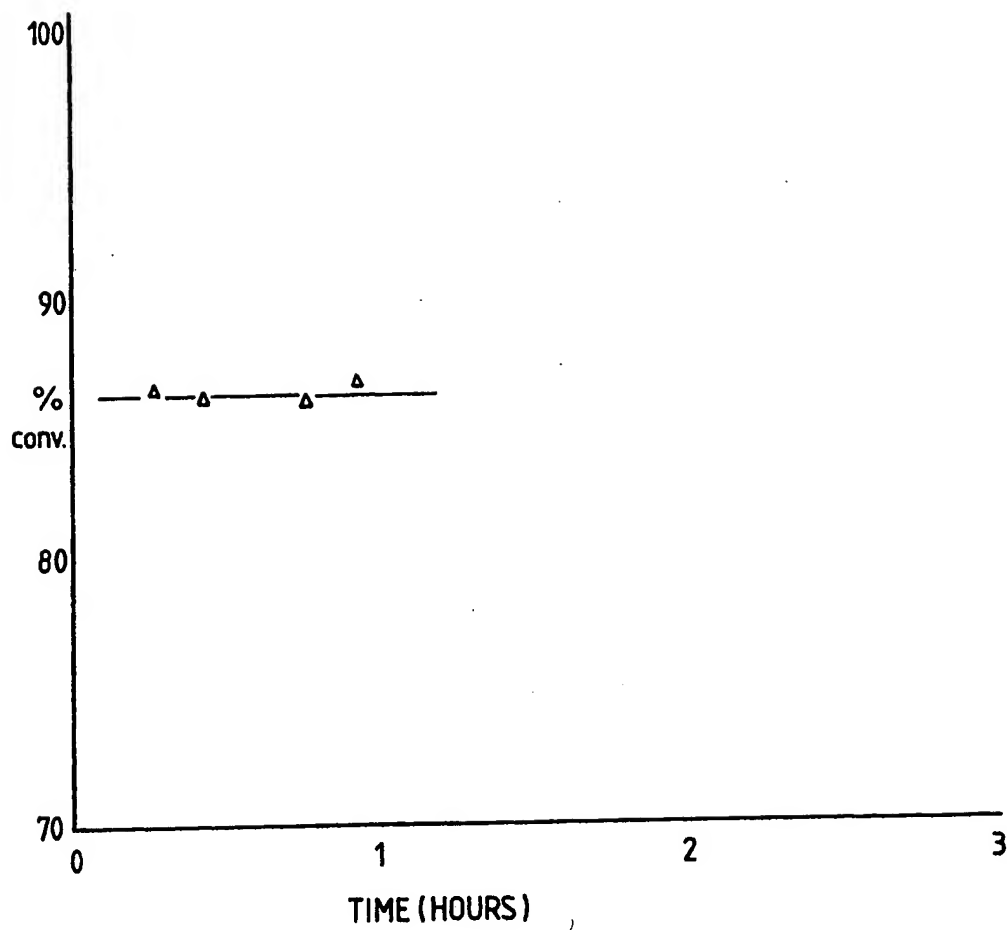


Fig.17.

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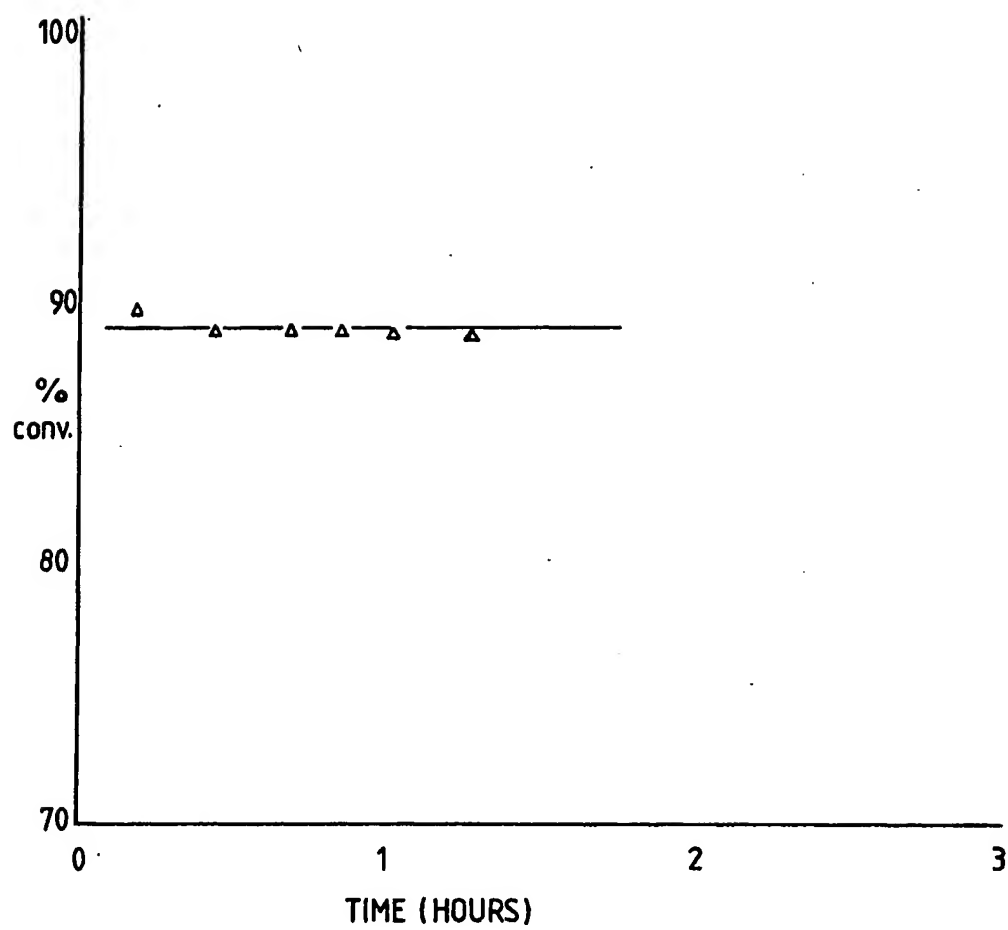


Fig.18.

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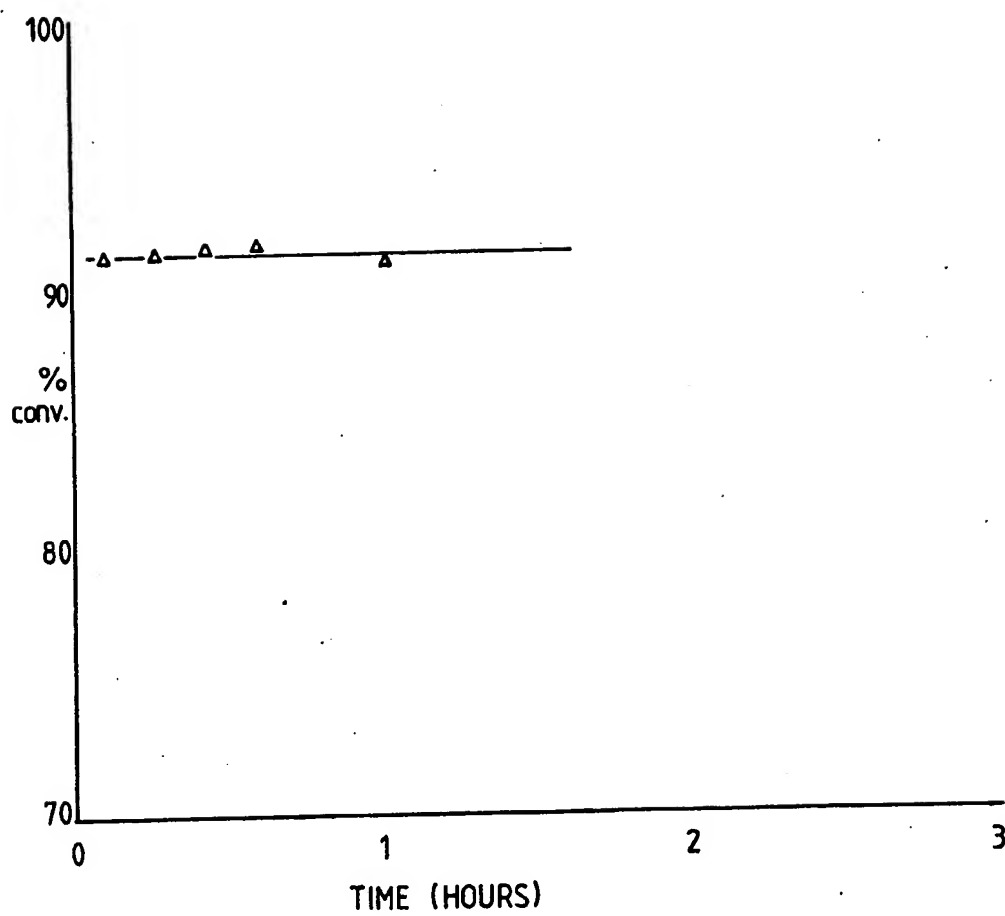


Fig.19.

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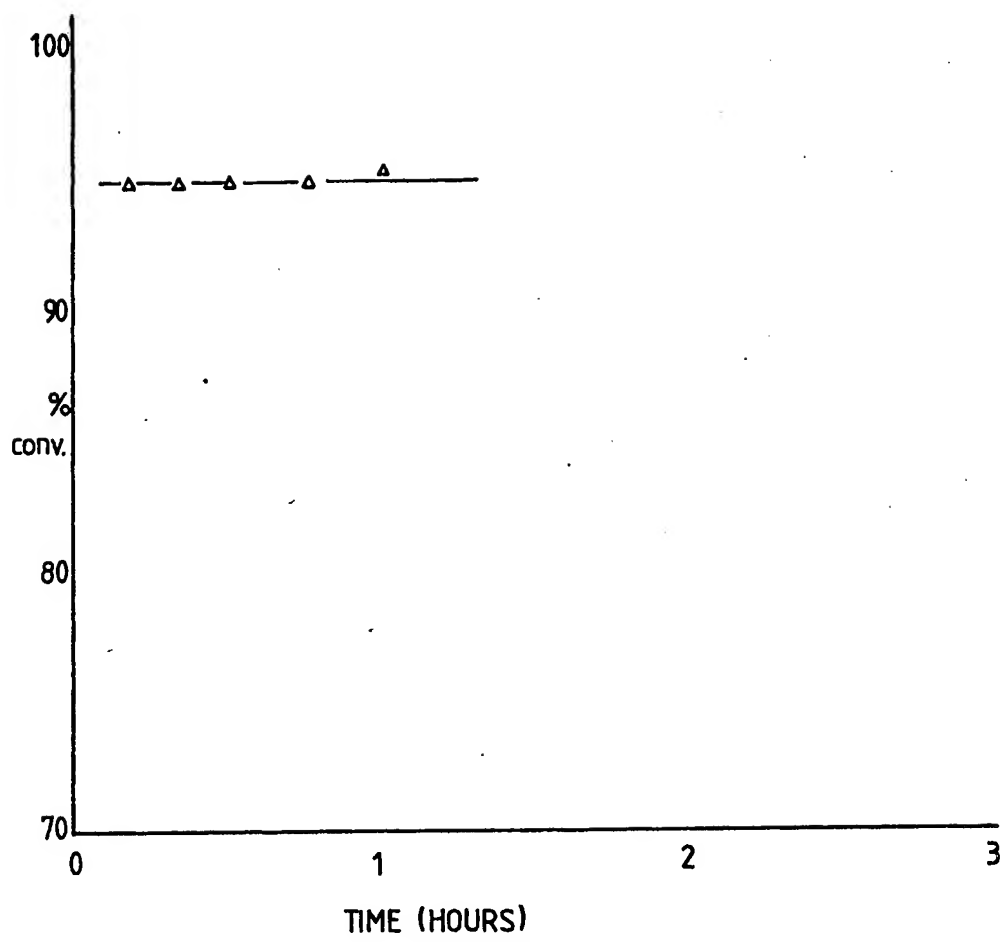


Fig.20.

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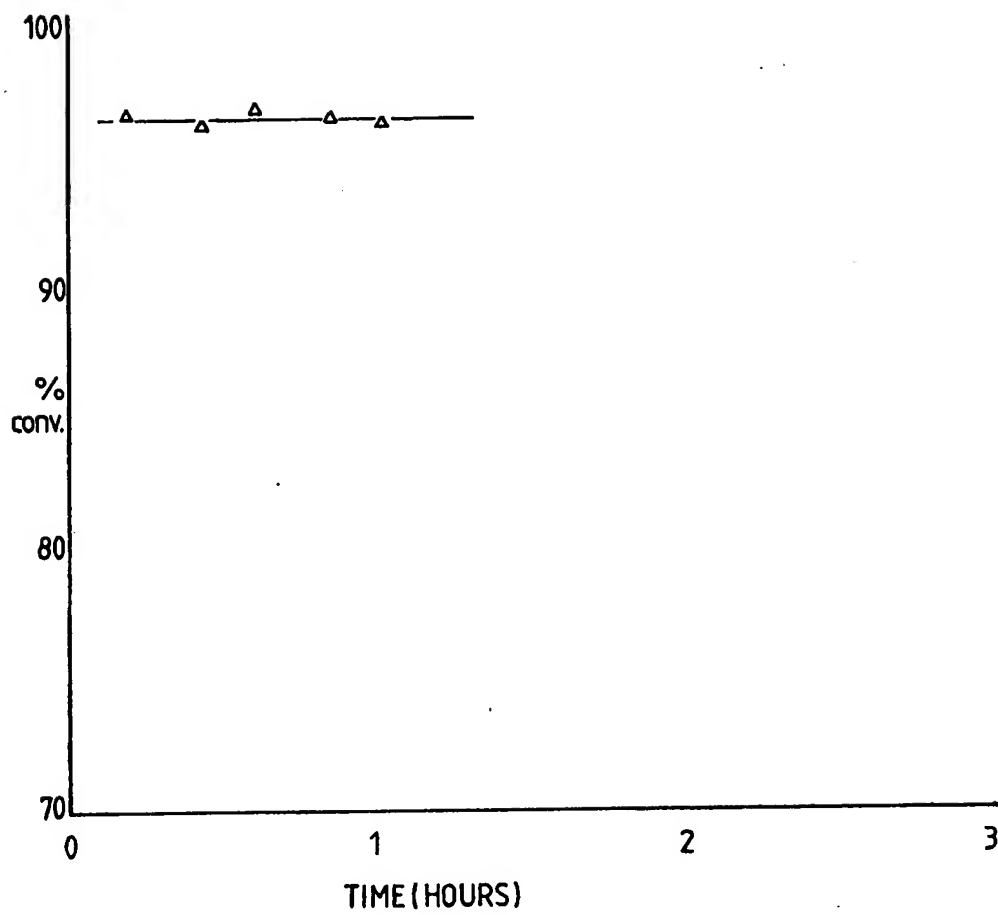
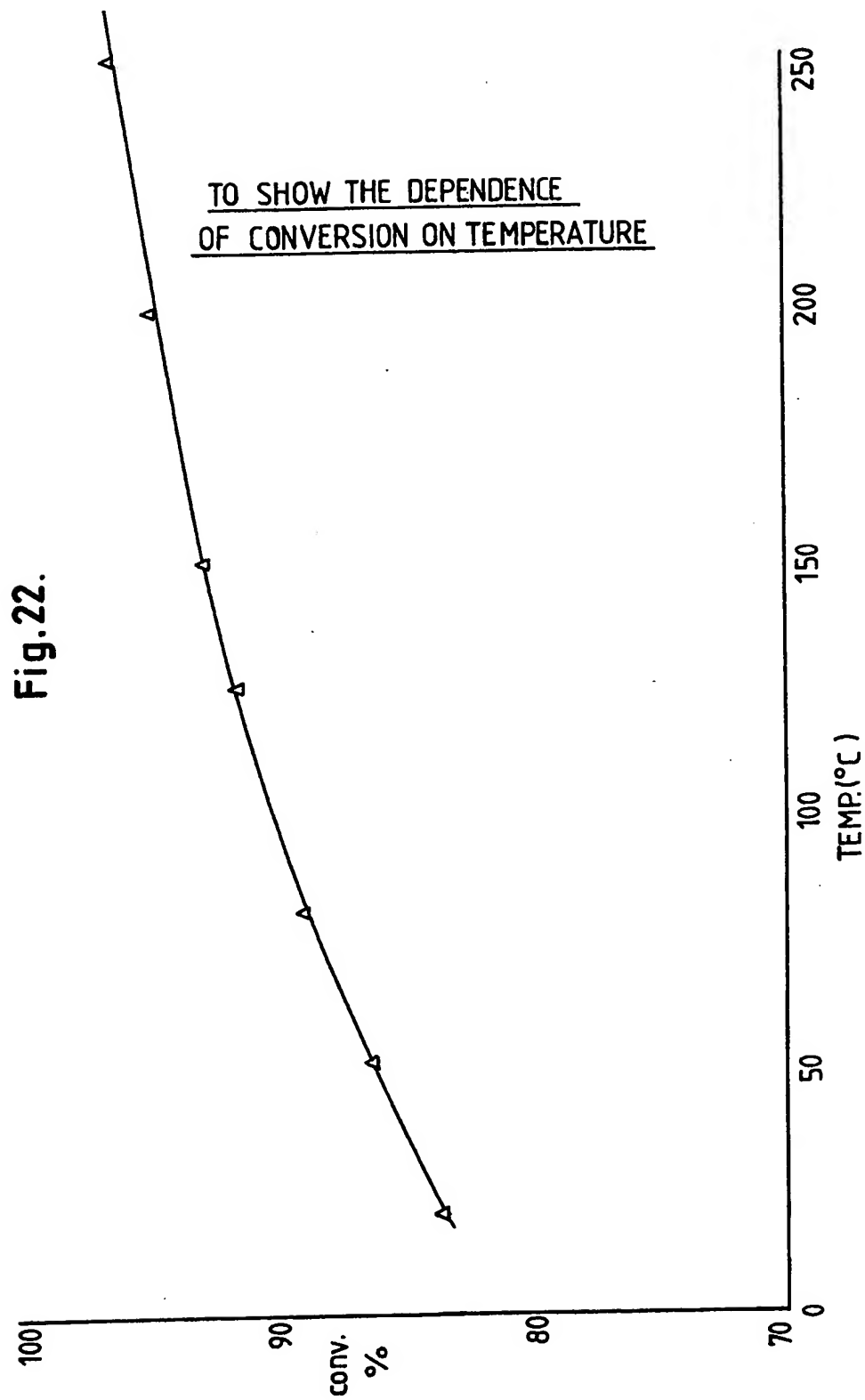


Fig.21.

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SPECIFICATION

Ozone removal

This invention relates to the decomposition of ozone and in particular to the catalytic decomposition of ozone.

5 Ozone is thermodynamically unstable and will decompose slowly at 250°C in the absence of a catalyst. The odour of ozone is perceptible at a concentration of less than 1 ppm in air. At concentrations greater than 2 ppm ozone causes irritation in the respiratory tract and damage to tissues occurs at higher concentrations. The presence of ozone, even in small concentrations, in the environment is undesirable.

10 Ozone may be removed from a gas stream by a number of methods such as gas scrubbing, thermal decomposition and gas adsorption. Apparatus for either gas scrubbing or gas adsorption requires maintenance and it is not always suitable for use when space or weight is at a premium.

Ozone is often produced as an unwanted by-product in photocopiers and similar apparatus which can result in oxidation of metal components. It may also be present in such a concentration that people 15 working in the vicinity may be affected. Ozone is sometimes used in the treatment of sewage and a quantity of it may remain at the end of the treatment. The gas, ozone may also be found in the vicinity of arc lamps, welding and any high voltage sources.

Ozone is present in the air at heights above 25,000 feet. At heights from 25,000 to 30,000, for example, its concentration will be between 0 and 20 ppm and at 30,000 to 55,000 feet between 20 20 and 20,000 ppm. Air for the cabin of an aircraft normally enters via a primary compressor of one or more of the aircraft engines, passes through the cabin and is released to the atmosphere by a valve. This controls the pressure of the air in the cabin which is normally kept at approximately 63 cm Hg, equivalent to the air pressure at a height of 5,000 feet. Since a number of aircraft cruise at between 25,000 and 30,000 feet and there is a high through-put of air through the cabin, the passengers and 25 crew are exposed to above average concentrations of ozone.

An object of the present invention is to remove at least a portion of any ozone present in a gas stream.

According to the present invention a process for the removal of ozone from a mixture of gases, containing ozone, comprises passing the mixture of gases over a catalyst such that at least a portion of 30 the ozone undergoes catalytic decomposition into oxygen, the said catalyst comprising catalytic material including one or more members of the group consisting of Pt, Ru, Rh, Pd, Ir, Os, Fe, Co, Ni, Ag, Mn and Sn alloys, mixtures and compounds containing one or more of these metals.

The catalytic material may be deposited on a ceramic or metal support and a layer of refractory metal oxide may be interposed between the catalytic material and the support.

35 The layer of refractory metal oxide, the so-called 'washcoat' may comprise one or more oxides of B, Al, Ba, Sr, Ca, Mg, Be, Si, Ti, Zr, Sc, Y and the rare earths. Preferably the washcoat loading should be between 0.2 g/cu.in. and 2 g/cu.in. of the support and we particularly prefer the loading to be between 0.4 g/cu.in. and 1 g/cu.in. The catalyst loading of the platinum group metals is preferably within the range 20 to 200 grams per cubic foot whereas the loading of the remaining catalyst metals listed above 40 is preferably within the range 50 to 1,000 grams per cubic foot considered relative to the weight of the washcoated support.

The support which may comprise channels extending from one face to an opposite face may be made from a ceramic material such as cordierite or a base metal or a platinum group metal or an alloy containing a platinum group metal. Preferably, the support is made from an oxidation resistant metal or 45 alloy and we particularly prefer Kanthal D or an iron alloy containing chromium and aluminium such as Fecralloy (Registered Trade Mark). The composition of Kanthal D is (% w/w) chromium 23%, cobalt 0.5—2%, aluminium 0.7% and balance iron.

The cell density of the support, that is, the number of cells or channels across the face of the support, is preferably 200 cells/sq. in. and above we prefer 350 cells/sq. in. and above.

50 The preferred catalytic material is chosen from the group consisting of Pt, Pd, Fe, Ag and Mn and, of these, we particularly prefer Pt, Ag and Mn.

The catalytic material may be or may be derived from an integral part of the support. When the support contains one or more platinum group metals, for example, these may constitute the catalytic material. Similarly when the support is of an alloy containing iron, iron compounds formed on the 55 surface by the corrosion of the metal may act as catalytic material.

To study the parameters involved in the catalytic decomposition of ozone a number of catalysts were tested in a tubular reaction. The catalyst samples comprised a catalytic material deposited on a metal support of Fecralloy having the composition of (% w/w) chromium 15.0%, aluminium 4.5 to 4.8%, yttrium 0.4 to 0.5% and balance iron), 1 inch long and 2 inches in diameter, the said support carrying an 60 alumina washcoat. The loading of the washcoat was 0.7 g/cu.in. In the tubular reactor, a stream of gases containing ozone was passed through the catalyst. In order to do this, a gas stream containing a mixture of nitrogen and oxygen was first passed over an electric heater, to enable the temperature of the gases to be adjusted, before ozone, produced by high voltage discharge, was added to the gas stream. The concentration of the ozone present in the gas stream was substantially 1.5 ppm. This concentration

was measured by a Dasibi, model 1003, ozone analyser, before and after the catalyst. The space velocity was $325,000 \text{ hr}^{-1}$ and the gas pressure 15 p.s.i.g. (29.7 p.s.i.a.).

A series of test were conducted with samples of catalyst employing different catalytic materials. The cell density of the supports used was 400 cells/sq. in. and the temperature of the gas was at 150°C.

The results are given in graphical form in the attached figures 1 to 22 and certain details of the tests and the figures in which the results are displayed, are set forth in the following tables 1, 2 and 3.

TABLE 1

Catalytic Material Deposited on the Washcoated Support	Loading of Catalytic Material – g/cu.ft. of Washcoated Support	Fig.
Platinum	120	1
Platinum	120	2
5.5% Rh, 94.5% Pt.	120	3
35% Rh, 65% Pt	120	4
Platinum and Silver	Pt 120 + Ag 500	5
Palladium	120	6
33 $\frac{1}{3}$ % Pd 66 $\frac{2}{3}$ % Pt	120	7
Silver	500	8
Manganese dioxide (MnO_2)	500	9
Manganese sesquioxide (Mn_2O_3)	250	10
Trilon tetroxide (Fe_3O_4)	375	11

Table 2 below, relates to a series of tests conducted with platinum as the catalytic material at a loading of 120 g/cu.ft. on a number of supports with various cell densities. The temperature was kept at 150°C.

TABLE 2

Cell Density in Cells/Sq. In	Fig.
180	12
400	1
550	13
1200	14

These results are summarised in Figure 15, which is a graph of ozone conversion vs. cell density.

Another series of tests was conducted with platinum as the catalytic material at a loading of 120 g/cu.ft. on supports with a cell density of 400 cells/sq.in. The temperature of the stream of gases was varied, as shown in Table 3.

TABLE 3

Temperature of Gas Stream, °C	Fig.
20	16
50	17
80	18
125	19
150	1
200	20
250	21

Finally these results are summarised in Figure 22, which is a graph of ozone conversion vs. temperature.

- In all the foregoing tests, the maximum back pressure of the support was 8 mm Hg. This low back pressure is one of the advantages to be gained by using metal supports. A further advantage of these supports is that they may more easily be constructed with cell densities in excess of 500 cells per square inch, for example, than ceramic supports.

CLAIMS

1. A process for the removal of ozone from a mixture of gases, containing ozone, comprises passing the mixture of gases over a catalyst such that at least a portion of the ozone undergoes catalytic decomposition into oxygen, the said catalyst comprising catalytic material including one or more members of the group consisting of Pt, Ru, Rh, Pd, Ir, Os, Fe, Co, Ni, Ag, Mn and Sn and alloys, mixtures and compounds containing one or more of these metals.
2. A process according to claim 1 wherein the catalytic material is deposited on a ceramic or metallic support.
3. A process according to claim 2 wherein the support carries a first layer of a refractory metal oxide upon which a second layer of the catalytic material is deposited.
4. A process according to claim 3 wherein the refractory metal oxide layer comprises one or more of the oxides of B, Al, Ba, Sr, Ca, Mg, Be, Si, Ti, Zr, Sc, Y and the rare earths.
5. A process according to claim 3 wherein the loading of the first layer of refractory metal oxide falls within the range 0.2 g/cm² inch and 2 g/cm² inch of the support.
6. A process according to claim 5 wherein the loading of the first layer of refractory metal oxide falls within the range 0.4 g/cm² inch and 1 g/cm² inch.
7. A process according to any one of claims 2 to 6 wherein the catalyst loading relative to the total weight of the support and the first layer falls within the range 20 to 200 g/cm² foot for Pt, Ru, Rh, Pd, Ir and Os and within the range 50 to 1000 g/cm² foot for Fe, Co, Ni, Ag, Mn and Sn.
8. A process according to any preceding claim wherein the substrate is made from an oxidation resistant alloy comprising, apart from impurities, chromium 23%, cobalt 0.5—20%, aluminium 0.7%, balance iron.
9. A process according to any one of claims 1 to 8 wherein the substrate is made from an oxidation resistant alloy comprising, apart from impurities, chromium 15%, aluminium 4.5 to 4.8%, yttrium 0.4 to 0.5% and balance iron.
10. A process according to claim 8 or claim 9 wherein the catalyst support has a cell density of at least 200 cells per square inch.